



### Building Muscles, Keeping Muscles Protein Turnover During Space Flight

As we age we lose muscle mass and strength. The problem is a matter of *use it or lose it* and more — a fact to which any active senior can attest. An imbalance in the natural cycle of protein turnover may be a contributing factor to decreased muscle mass. But the answer is not so simple, since aging is associated with changes in hormones, activity levels, nutrition, and often, disease.

The human body constantly uses amino acids to build muscle protein, which then breaks down and must be replaced. When protein turnover gets out of balance, so that more protein breaks down than the body can replace, the result is muscle loss. This is not just the bane of aging, however. Severely burned people may have difficulty building new muscle long after the burned skin has been repaired.

Answers to why we lose muscle mass and strength — and how doctors can fix it — may come from space. Astronauts usually eat a well-balanced diet and maintain an exercise routine to stay in top health. During long-duration flight, they exercise regularly to reduce the muscle loss that results from being in a near-weightless environment. Despite these precautions, astronauts lose muscle mass and strength during most missions. They quickly recover after returning to Earth — this is a temporary condition in an otherwise healthy population.

Members of the STS–107 crew are participating in a study of the effects of space flight, hormone levels, and stress on protein turnover. When we are under stress, the body responds with a change in hormone levels. Researchers hypothesize that this stress-induced change in hormones along with the near-weightlessness might result in the body synthesizing less muscle protein, causing



Mission Specialist Scott Parazynski takes a blood sample from U.S. Senator John Glenn, Jr., during STS–95. Senator Glenn and Mission Specialist Pedro Duque were the first to participate in the protein turnover study. Data collected during STS–107 will be added to that from STS–95.

muscles to lose their strength and size. Astronauts, who must perform numerous duties in a confined and unusual environment, experience some stress during their flight, making them excellent candidates for testing the researchers' hypothesis.

#### Earth Benefits and Applications

- Hormone models derived from missions mean better treatments for muscle atrophy on Earth.
- Hormone therapy may be more than a treatment for post-menopausal women; it may be the route to healthier muscles for the aging population, people with metabolic problems, and astronauts.

**Principal Investigator:** Dr. Arny Ferrando, University of Texas Medical Branch, Galveston, TX

**Project Scientist:** Dr. Jacob Bloomberg, Johnson Space Center, Houston, TX

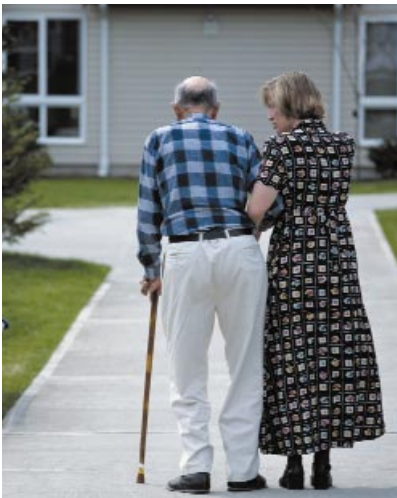
**Project Manager:** Angie Lee, Johnson Space Center, Houston, TX

## Background Information

### Science

Muscle protein is always being created and broken down. If something disrupts this process, by decreasing the formation of new muscle, or speeding up the breakdown of existing muscle, we lose muscle. It usually is part of aging and can affect people with metabolic problems, but researchers believe it is treatable.

Testosterone increases lean body mass and promotes muscle development during puberty. As we age, testosterone levels normally decrease from youthful levels. Stress and lack of physical activity may also cause a reduction in testosterone. Cortisol, a steroid produced by the adrenal glands increases as we age. Too much cortisol in the bloodstream can cause the muscles to lose much of their amino acid content. The muscle proteins lose these amino acids, which are used instead to make glucose in the liver. This may cause diabetes resulting from increased blood glucose levels, but also means an additional loss of muscle protein.



Loss of muscle can affect mobility and independence. A well-balanced diet and moderate exercise, combined with hormone therapy only if needed, may help the elderly and people with metabolic illnesses maintain and improve their strength.

During space flight, a decrease in testosterone and an increase in cortisol may be behind reduced muscle mass. Researchers will examine the effects of stress, hormonal levels, and protein turnover in astronauts. By studying the relationship between altered hormonal levels and changes in protein turnover caused by the stresses of space flight, researchers can apply this information toward preventing muscle loss in astronauts.

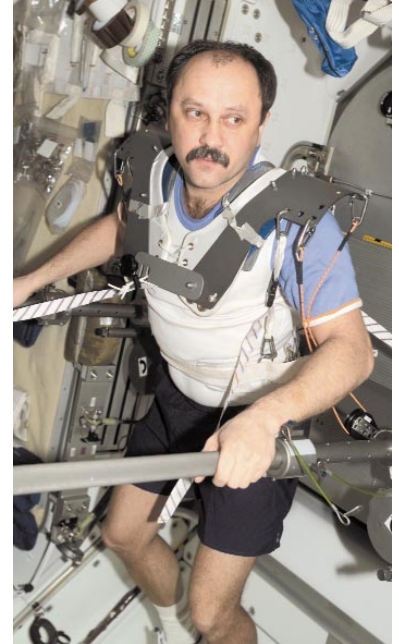
### Operations

Two months before launch, researchers use dual-energy X-ray absorptiometry (DEXA), a low-dose X-ray technique, to determine each astronaut's lean body mass. Blood samples are taken over three days, starting 60 days before launch. Before breakfast, astronauts give their first sample, and then they are given an alanine capsule containing a tracer chemical. Alanine is an amino acid that transports nitrogen throughout the body. By measuring the alanine and tracer in the blood, researchers know how quickly the body is creating muscle. Twelve hours after the first capsule, astronauts take 3-methylhistidine capsule labeled with a tracer. Three-methylhistidine, an amino acid produced when muscle is broken down, is used to determine the rate of protein breakdown. Another blood sample is taken 10 minutes later.

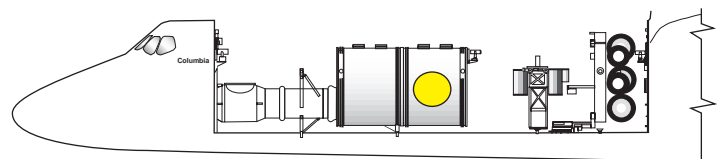
The sampling process is conducted twice before launch, twice during flight, and twice more after landing. DEXA whole-body images are collected before and after flight. Astronauts log everything they eat, medications they take, and exercise they do. Women also note where they are in their menstrual cycle. Findings from STS-107 will be compared to data from similar tests on the ground.

### Earlier Results

Studies focusing on healthy, active men suggest that muscle loss in older individuals may result from the body's inability to make muscle proteins. This may be a result of hormone imbalance, lack of physical activity, or poor nutrition. Furthermore, men over 60 with low testosterone levels who take supplements to maintain normal levels have increased muscle volume and improved strength within months of beginning treatment. Burn patients also experience better muscle development with testosterone treatment.



Yury Usachev, Expedition Two crewmember, wears a harness while exercising aboard the International Space Station.



Approximate location of this payload aboard STS-107.